Examining Process in Developing Products/Services in UK University Spin-off Context

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Abstract

Interaction or knowledge transfer activities between universities and industry have been observed and widely studied. One of the important categories of linkages and technology transfer is academic entrepreneurship, which includes commercial exploitation of technologies by academic entrepreneurs through setting up a company (Perkman, and Walsh, 2007). With unique and hybrid characteristics, university spin-offs are regarded as an economically compelling subcategory of high-tech start-up firms (Shane, 2005).The study of mechanisms in transferring technology that led to the commercial exploitation of university research through firm creation dates from the late 1960s (Landstr̈om, 2005). However, the product and service innovations of university spin-offs, the conversion of university research into a product and/or a service, as well as the creation of a product or service responding to the market demands (Shane, 2005) remain under-studied. There are gaps in knowledge about the transformation and transfer from academic research to the development of a market-driven product/service (Barr et al., 2009) and in how the product/service development process functions within the university spin-off context (Shane, 2005).

The data collected from in-depth interviews of 20 university spin-offs' founders are used to explore the processes by which products/services within the university spin-off environment are created and to answer the following research question: How is the process of product/service development of USOs organised? The findings show that the development processes, whether for products, services or software, are different from each other, one of the shared characteristics is that customers' requirements take primary and centre stage in the development process. Additionally, the development process is non-linear; a number of iterations occur during the process. This study has filled a gap in the academic entrepreneurship literature by shedding light on the process by which academic research is transferred and commercialised through the mechanism of products/services development. It also gives grounds for considering the notion that university spin-offs seem to bear a resemblance to the practices of small firms in product/service innovation, i.e. informal and non-linear products/services development processes.

Keywords: Academic spin-offs; product and service innovation; process of product and service innovation; university technology transfer

1. Introduction

Interaction or knowledge transfer activities between universities and industry have been observed and widely studied. The multi-dimensional characteristics of university-industry linkages (Agrawal, 2001; Bonaccorsi and Piccaluga, 1994; Grossman et al., 2001) include a range of avenues (Cohen *et al.*, 2002; D'Este and Patel, 2007; Faulkner and Senker, 1994) or 'mechanisms' (Meyer-Krahmer and Schmoch, 1998) by which knowledge and resources are exchanged and co-created between universities and industry. One of the important categories of linkages and technology transfer is academic entrepreneurship, which includes commercial exploitation of technologies by academic entrepreneurs through the setting up of a company (Perkman, and Walsh, 2007). With unique and hybrid characteristics, university spin-offs are regarded as an economically compelling subcategory of high-tech start-up firms (Shane, 2005).

The study of mechanisms in transferring technology that led to the commercial exploitation of university research through firm creation dates from the late 1960s (Landstr̈om, 2005). However, the majority of research into academic entrepreneurship and university spin-offs tends to focus on the infrastructural perspectives that support the creation of university spin-offs rather than on the firms' innovation and their technological offerings. The product and service development process in university spin-off firms involves converting university research into a product and/or a service, including assuring that a product or service is responding to the market demands (Shane, 2005). The study by Löfsten and Lindelöf (2005) suggests that university spin-offs are significantly different to corporate spin-offs with regard to the time taken in developing product/service, degree of modification of products and services, intermission between new patents and modification time. Yet, there are gaps in knowledge about the transformation from academic research to the development of a market-driven product/service (Barr *et al*., 2009) and how the product/service development process functions within the university spin-off context (Shane, 2005).

In addition, in a fragmented market where needs and demands of various customer groups differ, product/service offerings can become obsolete very quickly. Two important goals in product/service development that can help firms gain an economic return in such an environment are: i) speed to the market and ii) fit of the products/services to customers' needs (Schilling and Hill, 1998). Hence, the product/service development process is important for business to understand, since it illustrates activities including related managerial implications (Varyzer, 1998). Therefore, the data and findings of this article are used to explore processes by which products/services within the university spin-off environment are created and to answer the following research question:

How is the process of product/service development of USOs organised?

The data were collected from in-depth interviews with 20 university spin-offs' founders. The structure of the article begins with a discussion of processes involved in developing the product/service within university spin-off firms in order to address the question, using data collected from the in-depth interviews. Processes are examined by type of university spin-off, i.e. product, consulting and software firms. The article concludes with the academic contribution of the findings to both academic entrepreneurship and products/services innovation literature.

2. Theoretical background

2.1. Best practice of product and service development process

Many studies have explored best practice and determinants, which influence the successful process of new product and service development (Bessant and Tidd, 2011). For instance, Loch (2000) has underlined the best practice of product/service development exercise as customer focus, cross-functional collaboration, support from top executives, the presence of champion, and effective implementation of a defined process with appropriate assessment. Dooley *et al*. (2002) have identified four broad ways of defining strategic operation of new product/service development. They include project selection, objectives, product policy and customer engagement. Cormican and O'Sullivan (2004) have also highlighted the elements that impact on successful product/service development, such as scopes of policy and management, culture and environment, planning and selection, system and performance, and the team's interaction and cooperation. Kahn *et al.* (2006) have also proposed seven aspects of product/service development: strategy, process, market research, people, and metrics and product/service performance evaluation.

The process of new product and service development – progressing across from concept to successful products and services - is a continuous process and practice for lowering risks and uncertainty in the course of a sequence of solutions to problems as well as connecting market demand with technology. It proceeds through the stages of searching and choosing and into execution (Bessant and Tidd, 2011). Different models try to clarify how the product/service development process is structured and managed, from an idea to commercialisation of the product and service. The model that is usually referred to is named the linear model, which arises from an economic viewpoint where cash outflows occur prior to cash inflows (Trott, 2008). Another model that has been widely adopted in the business is the stage-gate model. A stage-gate process for product and service development is a theoretical and operative diagram for progressing new product and service plans from concept to market launch and further - a system for organising the process of new product and service development to increase productivity and proficiency. It has often been shown that unsuccessful projects are spoilt by omitted stages and actions, weak organisational strategy and direction, insufficient quality implementation, inaccurate information, and slipped deadlines (Cooper, 2004).

However, the superseding emphasis on ordered and sequential process structure is likely to disregard the elements that lead to the ability to innovate, such as flexibility, feedback and informality (McCarthy *et al*., 2006). Much current research proposes instead that the non-sequential process with cross-functional interaction should be comprehended. There is a growing consensus in the literature on product/service innovation that, for the success of products/services development projects, different development processes are required in different settings and environments (MacCormack and Verganti, 2003). In other words, the performance effect of development practices is mediated by the context in which product/service development practices operate. Ettlie and Rosenthal (2011) point out that there seem to be dissimilarities in how the innovation process is approached between manufacturing and services because of different systems in organising the development of new offerings. In addition, in the software development context, the generic product development process is often criticised for being excessively systematic and for not sufficiently taking into consideration the dynamic characteristics of software development, where requirements are usually challenging to exactly identify and finalise (Clark and O'Connor, 2012).

2.2. The development process in products/services within university spin-offs

Within the university spin-off context, there is a lack of knowledge about the conversion from emergent academic technology to the development of a market-responsive product/service (Barr *et al.*, 2009) or how the product development process operates (Shane, 2005). Based on the discussion by Shane (2005), elements of the process that university spin-offs from MIT undertook to develop the product/service are outlined. For instance, new technologies of university spin-offs usually have to be altered in order to transform them into products/services as well as to be suitable for the business environment. These alterations consist of tasks, such as improving performance, increasing robustness, building in supporting technology, scaling up for manufacturing, making them user-friendly and modifying mechanisms and architecture. In addition, since academic research or technologies are usually embryonic at the stage when the spin-off firms are established, an application to the market of these novel technologies needs to be chosen. Several foci are required in order to select in which market applications to deploy the technology, for example, marketability, sales volume, value to the customer, and the ability to gain a competitive advantage. Acquiring feedback from clients/consumers new technologies also needs to be factored into the process in order to allow the development of an effective product or service. Even though these elements provide useful insights and considerations for the development process of products/services of university spin-offs, these are not always clear in terms of the arrangement of development activities, for example, which activities kick start the development process or when a customer's feedback is sought. Since there is a gap in the knowledge about product/service development process among university spin-offs, this has raised a question of whether structured and formal product/service development process, as in larger or big firms, can be assumed and applicable to new and small firms that are created from university environment, such as university spin-offs.

Given the heterogeneous nature of university spin-offs and the different development practices required by different kinds of projects, this study adopts the typology proposed by Druilhe and Garnsey (2004), i.e., development, product, consulting and software. This typology provides a useful basis and foundation for analysing the data (from in-depth interviews) on the products/services development process of spin-off companies, since it recognises and encapsulates the different nature of university spin-offs. However, the products/services development process of 'development' companies is not presented here since 'development' firms, according to Druilhe and Garnsey (2004), commercialise their technology through a licensing model. This means that their offerings are based purely on innovative technology without additional development to transform it to meet the demands of customers or markets. Hence, the discussion of products/services development processes is concentrated on the other three categories, product, consulting and software firms.

3. Research methodology

This research aims to explore and explain various aspects of process in developing products/services of university spin-offs. Given the nature of the research question of this study, i.e. exploratory, the qualitative method, i.e. in-depth interviews with founders of university spin-offs, is employed to explore the process of product/service development. Therefore, the data analysis used in this study is the content analysis of interviews.

3.1. The sampling process

The sample used in this study involves the collation of university spin-off companies in the UK that are still active across all industries.

a) The population

The population in the study is university spin-off companies in the UK. According to the report by Higher Education Funding Council for England (HEFCE) 2010-11, the number of three year-old or older spin-off companies is approximately 1,000. In this study, while the definition given by HEFCE[1] is followed, the scope is more focused on spin-offs firms that have been established by academic or university staff rather than students, since they give specific scope to identify the population. In addition, firms in the service sector, in which firms are set up without any appropriating of IP, are included as well as technology-based spin-off firms.

b) The database development and sampling frame

The development of a university spin-offs database, which was used as a sampling frame of this study, was drawn from public websites of universities in the UK. The list of 133 universities was obtained from the Universities UK (http://www.universitiesuk.ac.uk), which is the central organisation representing all universities in the UK. The list was cross-checked with those provided by HEFCE and the Scottish Funding Council (SFC). The database of university spin-offs was constructed by searching through the business and innovation centres of universities, such as Isis Innovation (Oxford University), UCL Advances (UCL), University of Manchester Innovation Centre (University of Manchester) and Imperial Innovation (Imperial College, London) as well as departmental websites. Since some universities do not provide a list of spin-off firms on their public website, the relevant people in the university were contacted to ensure that there was no omission of any university spin-off firms. The data were merged and reconciled with the company list shown on website: www.spinoutsuk.co.uk, which provides a comprehensive list of all spin-off companies from universities in the UK.

In order to ensure that these are university spin-offs from academic or university staff, the names of company directors were checked against the university's website to see if they were affiliated with the university. From 1356 spin-out companies in the database, 844 companies are actively in operation. In addition, 87 companies have been merged or acquired (M&A) (these companies are simply excluded because after M&A, they have become part of a big conglomerate and tend to be less constrained by resources). Within the active companies in the database, there is no information available on 144 companies. This process also helped in the collection of founders' contacts, i.e. name, e-mail and telephone number, for the purpose of the empirical research.

c) The population size

Even though the report by HEFCE 2011-12 showed that the number of three year-old or older spin-off companies is approximately 1,000, through the database development process, only 844 university spin-offs are eligible.

[1] The definition set in the Higher Education Business-Interaction (HEBCI) surveys HEFCE)is broad and expansive by embracing new legal entities and enterprises created by Higher Education Institutes or their staff to allow the commercialisation of knowledge from academic research. The universities may or may not have a stake in these firms. In addition, the term "spin-offs" includes start-up firms established by university staff and students beyond the exploitation of IP

3.2. Data collection

Data collection was designed to explore the process of product/service development. The data were collected through qualitative research. In-depth interviews were conducted with 20 academic founders of university spin-offs. The sample at this stage was selected from the database developed as explained in the sampling frame section, aiming to represent the various sectors, firms' size and different regions in the UK that university spin-offs operate in. The respondents were selected based on the following criteria:

- being a founding member of a university spin-off firm
- owning an equity in the firm
- previously/or currently holding an academic position when establishing the company
- having product/service offerings in the market

Convenience played a secondary role in the selection process, i.e., how easy it was to get access and to get an agreement from the founders to set up a 30 to 45 minute interview.

Table 1: Summary of spin-off firms and respondents' profile

Company	Gender	Typology	Sector	Company location	How the interviews were conducted	size	Maintain academic position
Company 1	Male	product	design/engineering	London	Face-to-face	micro	no
Company 2	Male	service	management consultancy	London	Face-to-face	small	yes
Company 3	Female	software	software	Scotland	Telephone	micro	no
Company 4	Male	product	biotech	London	Face-to-face	small	yes
Company 5	Male	software	software	East Midlands	Telephone	micro	yes
Company 6	Male	service	charity	Scotland	Telephone	micro	no
Company 7	Male	service	consultancy	London	Face-to-face	micro	yes
Company 8	Female	service	biotech	North East England	Telephone	micro	yes
Company 9	Male	software	software	London	Face-to-face	micro	No
Company 10	Female	service	biotech	London	Face-to-face	small	yes
Company 11	Male	product	engineering	London	Face-to-face	micro	yes
Company 12	Male	product	pharmaceutical	North West England	Telephone	micro	yes
Company 13	Female	service	consultancy	Yorkshire	Telephone	micro	yes
Company 14	Male	product	geography	East Midlands	Telephone	micro	yes
Company 15	Male	software	software	East Midlands	Telephone	micro	no
Company 16	Female	product	biotech	South East	Telephone	small	yes
Company 17	Male	software	software	East Midlands	Telephone	micro	yes
Company 18	Male	software	software	Wales	Telephone	micro	yes
Company 19	Male	service	consultancy	West Midlands	Telephone	micro	yes
Company 20	Male	product	engineering	East of England	Face-to-face	medium	yes

4. Findings

Based on the evidence from the in-depth interviews with 20 founders of university spin-offs in the UK, the illustrations of development processes of products, services and software within the university spin-off context were derived to address the main research question: *How is the process of product/service development of USOs organised?* They are presented and discussed in the following sections.

4.1. Product development process

For product firms, the development of product starts from idea/concept, research or existing product. These ideas are then often either published in journals or patented. As shown in one of the examples from the interviews, a medical device and an engineering product have been developed from a published paper or patent. With an awareness of market demands or interests received from potential customers/clients, the design was then developed, the prototype was built, production started, and the product was subsequently launched in the market. However, this process does not occur stepwise.

After the introduction of the product into the market, customers' feedback is gathered in order to improve features of the product. The whole process is encapsulated in Figure 1. However, the product development process outlined here attempts only to capture the main activities of the product development process within university spin-offs in which these activities are joined together to establish a process. It is noted that the product development process is also dependent on context. In other words, the type of product being developed specifically determines the arrangement of the product development process (Trott, 2008). The following are explanations of the product development processes from in-depth interviews with university spin-off founders:

> "…… it's really one of making a lot of prototypes and experimenting very quickly with different designs. So, initially, we make a prototype very, very quickly. That allows you to quickly determine if a design has any potential or not, I think a different route to designing a product than spending a lot of time trying to come up with a final design and then developing it and testing it to see if it works. It's about iteratively testing it and quickly changing…changing the design." (Male, design and engineering spin-off firm in London)

> "…….We initially had the idea to use this technology for the diagnosis of allergy. Then em…we published a paper. Then…there were several bottlenecks in translating this concept into a product, mainly because the technology was very, very complex, very expensive, and totally unsuitable for any diagnostic environment….. we developed a device, which is also part of our [patent support folio] that has …the function to enable the…to carry out a very complex task, which require incubation arrangements, under time-controlled condition, on a lateral flow platform. So, what we did then, we patented a device that still…while still incorporating the concept of a lateral flow, which dramatically reduced the cost and the processing of downstream instrument, Then we patented, and the patent was, in principle, granted everywhere. And then, then we built an instrument that was able to handle the device, add the agent to the device, and read the device. …… this was the concept – now to translate this concept into something that you could touch… So then the TTO found a partner to make a co-investment. Then, I think, myself and colleague, we managed to raise more than £3 million of grant funding, and this allow us the completion of the…technology [process] and into product, and so we reached the prototype stage. So, we have the fully functioning instrument prototype and we had fully functioning device. At that stage, when we reached the prototype development, so we needed to find other source of funding for moving from prototype to production." (Male, biotech spin-off firm in London)

> "we had some research, which em…well, which didn't actually make a product at all, but simply showed that it would be possible to design a product. So, what we did within the company, probably one of earliest decisions was that we recruited…we recruited both em…radio frequency engineers and software engineers to do product design work to incorporate the research that we had licenced. So that was done by people, you know, who professionally design pieces of hardware for a living, so that the product design was done entirely within the company, but made use of the licensed research." (Male, engineering spin-off firm in East of England)

This product development process shown above is similar to the network model of new product development proposed by Trott (2008), which characterises a general and theoretical view of the product development process. The initial activities are described as knowledge gathering and finding business opportunities. The activities, such as product concept development and development of product prototypes, are the transformation of an idea or concept into a physical form. Then, the product starts to attain physical features, such as shape, form, size, colour and weight. Finally, market and technical testing are conducted, followed by the launch into the market. The testing and screening is noted as a continual process and occurs of every stage. This also confirms the iterative process of product development.

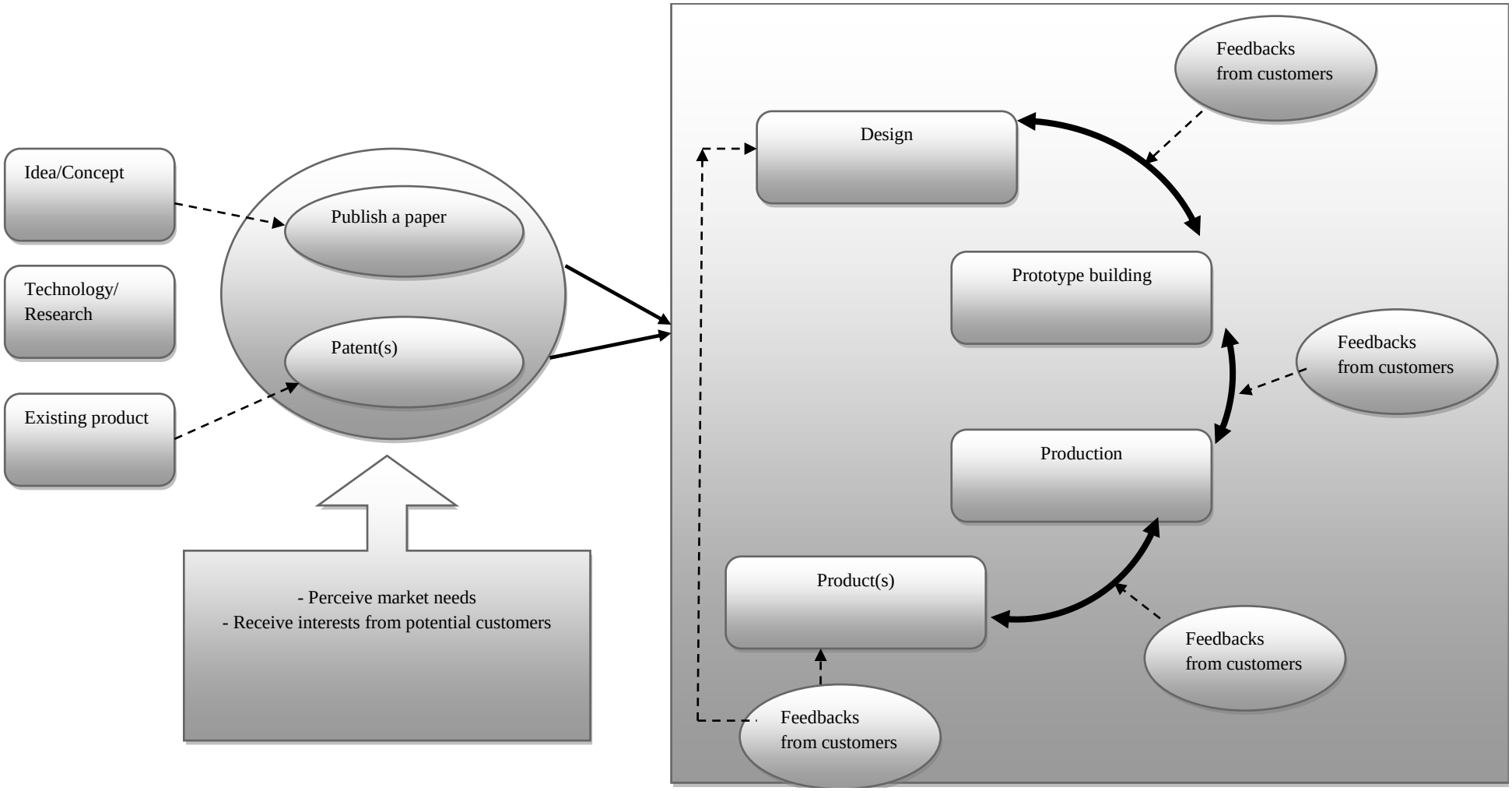


Figure 1: Product development process within university spin-offs
Source: Author's survey

4.2. Services development process (for consulting firms)

For service companies in this sample, the development of a service begins with research or concept, followed by academic paper publishing. They either recognise market demands or receive interest from potential customers and clients. For example, a consulting or testing service has been developed from the identification of gaps in the market or from customers' needs and then customisation of the research matches market demands. In other words, the research is optimised or applied to clients' problems. Along the way, the development of the service is carried out in conjunction with customer feedback and inputs. The outcome of the service provided to particular clients/customers has some potential to become an academic paper. Nevertheless, the service development process of university spin-offs outlined here is intended only to describe the main activities of the service development process within university spin-offs, in which these tasks are linked together to allow a process to take shape. Again, the management of the service development process is specifically dependent on the service offered and the specific needs of customers. Figure 2 captures the process of service development. It is noted that the process does not occur in steps and that there are a number of iterations along the process. The following are explanations of the service development process from in-depth interviews with university spin-off founders:

> "So…what our company sells really is research and consultancy as a service, and so, we use research methods which are fairly standard in the Social Sciences. So, I'd say that the methodological training in those I had from my undergraduate days, from my Masters, from my PhD, and so they definitely inform how we, as a company, operate, and what we can offer our clients. And then, if you add on top of that a lot of experience of interacting with clients, understanding when we've done a job that really works for them – then we can optimise and tailor and customise what we do, depending on our feedback." (Male, consulting spin-off firm in London)

> "It came from the research that we've been doing for the last 20, 30 years, but it also came from a hole, a gap is what I should say, a gap in the market. So we believed we had…we had a test which could be adapted to do this and, in fact, we've patented it now. So, it came from the market and also from the fact that we had innovative technologies within the University. We developed it from that by going to conferences, going to the Industry Association meetings, going to European meetings, having one-to-one contact with people, and that's how we developed and we're still developing the business that way. We're a service-provider, so the products to be tested come to us from the company. We…we develop a contract with them, which has a detailed protocol of what we're going to do. That's agreed, the pricing is agreed, and then we start the – confidentiality agreement is in place. We receive the products to be tested, and we do it within a particular timeline." (Female, biotech spin-off firm in North East England)

> "…… the data from the research, we would evaluate and analyse, so we'd produce more academic articles and disseminate that through…back [into] professional journals. …our policy would be to produce…to focus on research. So, we developed a research tool for clients, which combined our model with…so competencies specific to the clients. ….. we would have three aspects to the company: the research; turning the research into products; and the third element was applying that in consultancy and development." (Female, consulting spin-off firm in Yorkshire)

The service development process within university spin-offs has some elements that are similar to the new service development model suggested by Johnson *et al*. (2000), in terms of the design and formulation of new services, the analysis of market opportunity and the service design testing (with customers). In addition, each stage is performed several times as a result of customer feedback. However, there are some elements that are different between the new service development model (Johnson *et al*, 2000) and the

service development process – university spin-offs. In the model by Johnson *et al* (2000), actors, systems and technology are emphasised as having a vital role in the process of new service development, while within the university spin-off context, as found in this study, these aspects were not identified as important.

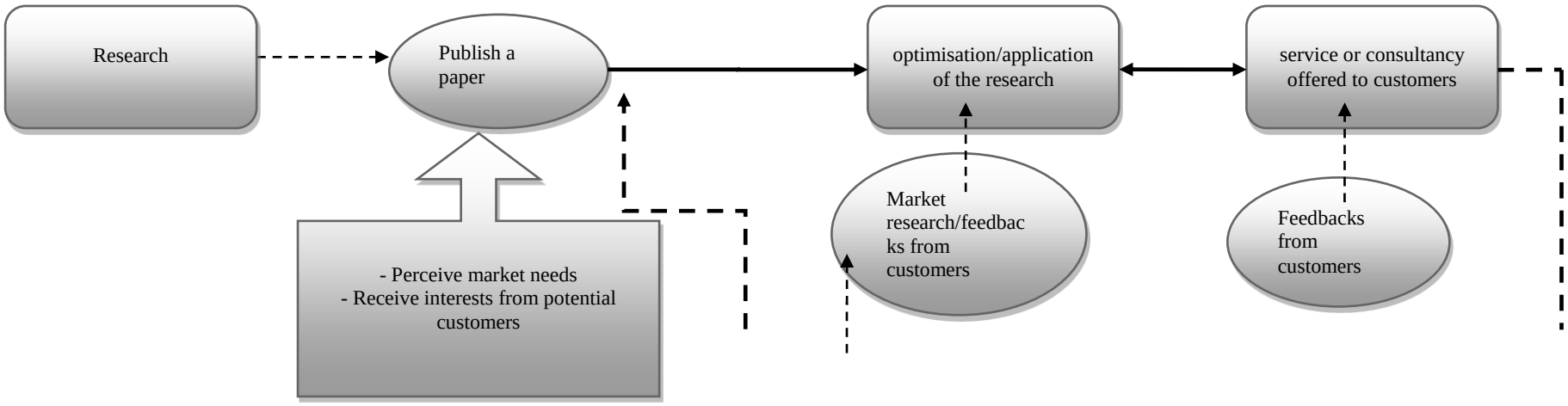


Figure 2: Service development process within university spin-offs
Source: Author's survey

4.3. Software development process

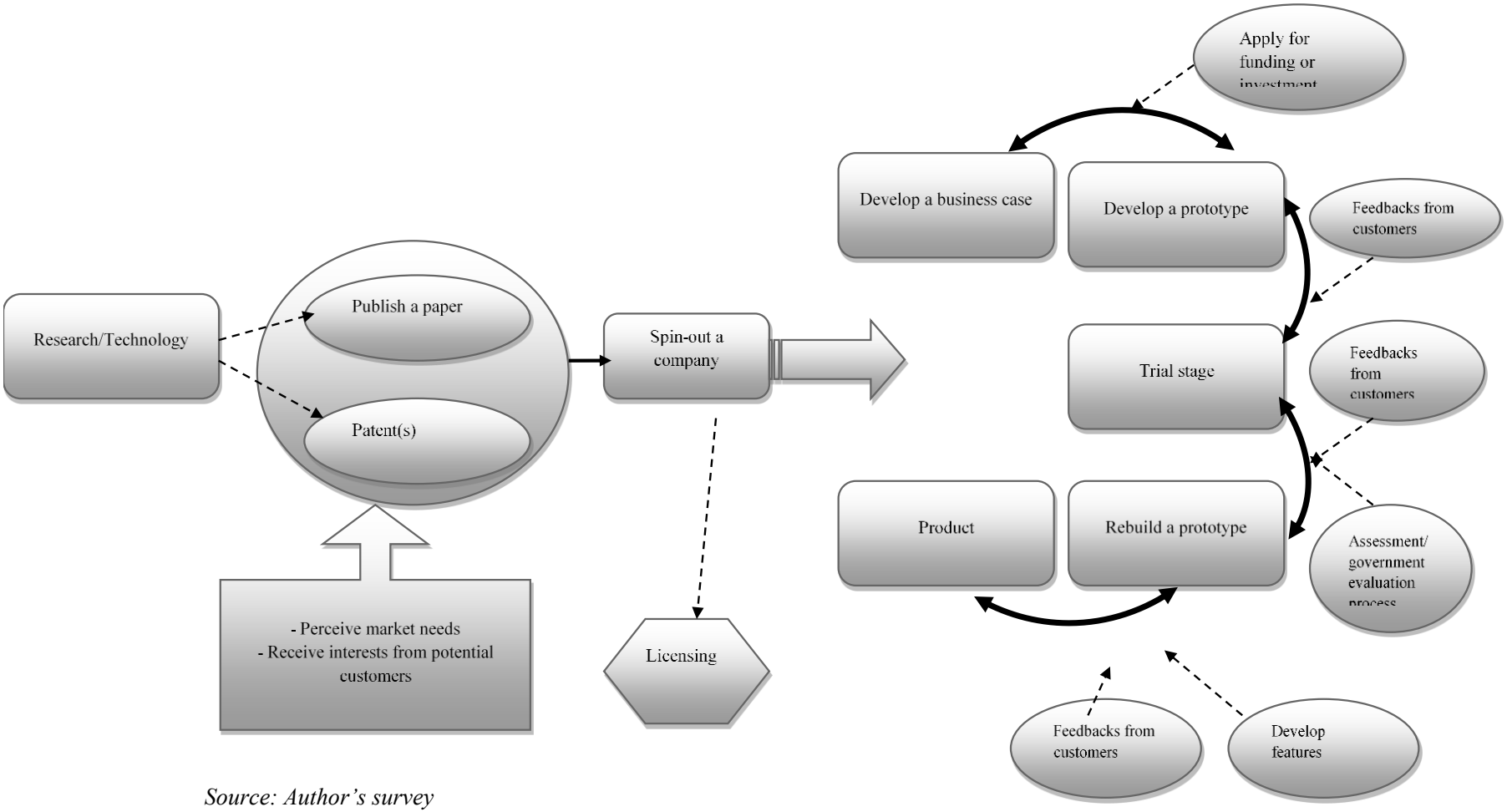
In software companies, the development of software starts from either patents or research papers. Similar to product and service development processes, founders either recognise market demands or receive interest from potential customers and clients. Then, the company is set up incorporating licensing activity. Subsequently, the business case is developed for application to funding or investment; one or more prototype are developed and piloted with customers' feedback along the way. In addition, some types of software require governmental assessment. Feedback from the governmental evaluation process together with customers' comments allows the adjustment and refining the prototype. The software product is then developed and launched; with inputs from customers, and different features used to improve the software. Figure 3 portrays the process of software development. Again, it is noted that the process does not happen in stages and that there are a number of iterations. The following are explanations of software development process from in-depth interviews with university spin-off founders:

> "The software was originally developed during a PhD course of study. …. during the PhD, we published the results of our research, and…and we also put a demonstration of our software online, on a website, and a couple of companies saw this research and they were interested in licensing it. So, at this point, the University, who owned the software, decided to form a spinout company to commercially license this software and to sell it to some other companies. The product, after the sort of research project, it was still very much a proof of concept. It wasn't really ready for…commercial use. There was a fair bit of development getting that software from a research quality product into a…a commercially ready product. The main…the main way we pulled it from the research project to a commercial project was basically just through listening to what the customers were looking for, what they…what they wanted to do with it, the problems they wanted to solve, how they wanted to use it, and that was our main focus of development." (Male, software spin-off firm in East Midlands)

> "…… at the end of the project, we would look at all the IP that's been created and look if there's scope for patenting. At the end, then, some patents are then chosen to process, to proceed further, to see if there's any scope for creating a spinout. So, we went through all that process. We actually had a prototype, working in real-time, and yeah, that was the basis of getting seed investment from TTO. So, they [TTO] raise public money and they invest in the companies. So, we went through a series of seed investment proof of concepts to show that we're hitting all our milestones." (Male, software spin-off firm in London)

> "I undertook PhD research and the development of a prototype [software] programme. Then, the…the universities then went through a knowledge and technology transfer process, where the prototype programme was translated into a more sophisticated form, platform, and went…underwent alpha and beta trialling. Then, following the completion of that, we then went through a series of international partnerships, and we went through, the health technology assessment and evaluation process in the United Kingdom, United States, Canada with a series of collaborations, research collaborations, here in the UK and the US. We worked very closely with our commercial services organisation, and we considered issues of branding, business models, etc., but also a complete rebuild of the software prototype using more updated technologies to develop a commercially viable product. If you think that, as a prototype, we then had to consider how we could convert that prototype into a more refined [design] and commercially robust product." (Male, software spin-off firm in Wales)

Feedback from different parties along the software development process provides a similar model to the feedback links model suggested by Kline (1985). In Kline's model there are three kinds of feedback links significant to successful innovation. Companies which are successful in innovation have usually managed these feedback links effectively. These suggest the refinement or rectification in a product that emerges from any faults or defects discovered. In addition, market-finding specifies evaluation of the product's effectiveness and competitiveness, which is vital to the design of later systems or product models.



Source: Author's survey

Figure 3: Software development process within university spin-offs

5. Discussion

It is clear from this study that customer' feedback is crucial in every step of product, service or software development. This point confirms the findings by Ettlie and Rosenthal (2011) that both product and service processes are relatively alike in terms of recognising and the prioritising the importance of customer feedback. Even when the product is launched, feedback from customers is still important in further improving the design of the product. It is evident that the product development process among product firms begins not only from cutting edge research or patents, but also by being focused on customers' needs. This agrees with the findings of the study by Isaksson *et al.* (2009); the concept of customer orientation has been widespread among manufacturing firms for decades. This suggests that market or customer needs play a primary role to the process (Ulrich and Eppinger 2007).

However, a difference between product and service development processes is observed. The service process is tailored to the specific needs of particular clients/customers. Therefore, the development process continuously involves customers; it is more of a relationship-based process (Gummesson, 2002). In the product development process, customer involvement tends to be more intermittent and occurs through prototype or product testing. In general, the service output is consumed by specific consumers/clients, while product output is standardised and for distribution to a wider market. The software development process of university spin-offs appears to resemble the agile software process. This means, the software is created by exploiting continual development and improvement of design and testing based upon prompt customer feedback and alteration (Dybå and Dingsøyr, 2008). These agile principles allow the changes based on acustomer's feedback to be responded to quickly (Hanssen and Fægri, 2008). Table 6 summarises the main characteristics of the development process of different types of university spin-offs in this sample.

It can be concluded that the findings of this study suggest that the processes for product/service innovation conform neither to the stage-gate model (Cooper, 2001) nor the linear model, which structures product development process through sequential stages and gates and emphasises on formal R&D (Santamaria *et al.*, 2009). Both models are still dominant within the practice of product innovations and are usually linked to product development of big companies where processes are routinized and formalised (Berends, *et al*. 2014).

The findings from our interviews endorse the studies that find that small firms (since most of spin-off firms in the sampling are categorised as small to medium firms) rarely follow formalised process structures in developing products/services (March-Chorda et al. 2002; Scozzi *et al*. 2005); instead they normally take on an iterative and flexible approach. Isaksson *et al.* (2009) also note that iterative processes should be emphasised even in the manufacturing sector – that development tasks should be undertaken in a synchronised iterative manner. As highlighted by Berends *et al.* (2014), small companies have used agile product/service development project planning and repeated the production, creation, selection, and alteration of targets and concepts. In addition, the product/service development process adopted by these small firms is much leaner than the generally acclaimed structured processes. There are no clearly defined steps or written procedures being used (Marion *et al.* 2012).

Table 6: Summary of main characteristics of development process of different types of university spin-offs

Characteristics	Product firms	Consulting firms	Software firms
Starting point of the development process	- research, patents or published paper - recognisation of market potential and customer demand	- research or published paper - tailor and adapt the research to solve client problems	- research, patents or published paper - recognisation of market potential and customer demand
Process	Design, prototype building and maufacturing	relationship-based	agile
Customer/user engagement	The use of customer feedback is extensive but periodically (through prototype/product testing)	The use of customer feedback is extensive and throughout the whole process	The use of customer feedback is extensive but periodical (through prototype/software testing). However, change based on customer feedback can be instantaneous.
Offerings/Outputs	- (tangible) produts, such as device or machine - output products can be standardised and served to a wider market.	- services, such as consulting or testing service - output services tend to only serve specific client/customer.	- software - softwares can be standardised and served to a wider market but some features can be adapted according to specific client requirements.

Source: Author's survey

Further, customer input plays a vital role in university spin-off contexts. It feeds into the development process throughout; it also determines the adaptation and iteration of the concepts and prototypes. This point also reflects the characteristics of small firms when developing products/services. They generally rely on their own clients' knowledge and information as well as market analyses rather than commissioned market research (Berends *et al.*, 2014). As noted by Marion *et al.* (2012), the minimal upfront market research is likely to be driven by resource constraints and a desire to get the product/service into the market as quickly as possible.

This observation offers grounds for postulating that university spin-offs tend to adopt the characteristics of small firms' product/service innovation practice. The finding on different processes adopted by university spin-offs also support the wider argument made in the product/service innovation literature, that the norms and principles of product/service development in small firms are fundamentally different to those of large businesses. The studies of product/service innovation should more clearly distinguish between companies of different sizes, instead of imposing the processes of big firms onto small businesses (Berends *et al.*, 2014). What is conventionally regarded as best practice (e.g., Kahn *et al.* 2006; Cooper and Kleinschmidt 1995), originating from the perspective of large firms, may not be applicable and useful to small firms such as university spin-offs.

6. Limitations

The data collected from twenty in-depth interviews has only explored and illustrated the processes in developing products/services of university spin-offs. They give an initial understanding and examples of how the process begins, various elements of each activity that connect to create the process, and the different product/service innovation processes employed by different firm types (i.e. products, consulting, and software). The data therefore does not conclusively represent the industries or sectors as a whole.

Additionally, during the process of data collection, in-depth interviews were only conducted with academic founders of university spin-offs rather than research and development managers or product managers, who subsequently joined these firms. This also limits the qualitative data and findings. At the early stage when the firms were established, academic founders had general and extensive knowledge on product/service development and had even performed the development of product/service from initial ideas or concepts. When the firms have expanded and increase their product/service portfolio, R&D or product managers are hired and would carry out the function of product/service innovation on a daily-basis. They would arguably have more current and ubiquitous information and knowledge related to product/service innovation. Hence, qualitative data from interviews with only academic founders are limited to particular a perspective on product/service development at the early stage of the firms.

7. Conclusion and further research

This article aims to explore the processes in developing products/services within the university spin-off context. The processes of developing products and services in university spin-offs in this study have been based on company's typologies, i.e., product, service and software (Druilhe and Garnsey, 2004). Although the development processes, whether for products, services or software, are different from each other, one of the shared characteristics is that customer requirements take primary and centre stage in the development process. Additionally, it is noted that the development process is non-linear; a number of iterations occur during the process. Evidence from the interviews confirms this point.

The findings of this research have contributed to filling a gap in the academic entrepreneurship literature. They shed the light on the process by which academic research is transferred and commercialised through the mechanism of product/service development practices. The findings also give grounds for considering the notion that university spin-offs resemble the practices of small firms in product/service innovation, i.e. informal and non-linear products/services development processes. Further, the findings confirm and support the wider argument in the product/service innovation literature that product/service development in small companies is fundamentally different to large firms. What is traditionally considered as best practice (e.g., Kahn *et al*. 2006; Cooper and Kleinschmidt 1995), initiated from the large firm viewpoint, may not be suitable ore relevant to small companies such as university spin-offs.

Since the processes shown in this study only give an initial illustration of how products and services are developed by broad firm types (i.e. product, consultancy, and software), further investigation of the processes of products/services innovation by sectors can be undertaken to present a clearer picture of how the processes of products/services are organised by sector or industry such as engineering, biotechnology, software, or various consulting/service providers. Then, a comparison and a more

focused picture can be obtained of how different are the development processes in which different sectors university spin-offs operate.

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